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Method and Device For Bending and Reshaping Profiles By Means of Roller Bending or Matrix Bending

Background

Field of the Invention

The present invention pertains to a method and a device to bend and reshape profiles through roll or matrix bending.

Discussion of Prior Art

The term "reshape" is understood to mean that a profile is produced from a straight panel section through a reshaping process, for example. The term "bending" is understood to mean that profiles that have already been finished are bent in an arbitrary manner in two or three dimensions. The term "roll bending" is understood to mean that the bending or reshaping process occurs by passing the panel section or profile to be reshaped or bent through a roll bending process. Such a roll bending machine consists essentially of a center shaping roll that lies opposite a center roll to the profile to be bent.

In the direction of travel of the profile, at least one support roll is located prior to the shaping roll and if necessary a guide roll opposite the support roll, and there can also be a bending roll behind the shaping roll. In the process, other guide rolls or slides can be provided. A roll bending process can also be accomplished in that a few of the rolls mentioned above are not designed as rolls, but as slides or pressure shoes.

The invention also pertains to not just the bending of profiles in general, but in particular the bending of hollow profiles. Thin-walled hollow profiles present the problem in that the danger exists of collapsing or breaking the profile during bending. In this case, it is preferred that a mandrel shaft be fed inside the profile, ~~said~~ mandrel shaft supporting the profile in the bending zone from the inside.

The invention also pertains to a method to bend and reshape using one or more matrices.

Such matrices are bending tools that consist essentially of slides as described in US 5,884,517, for example. In this case, the problem exists as well of reshaping and/or bending a complicated and thin-walled profile through multidimensional rotation, tilting and shifting of the individual matrices.

All of the bending and reshaping processes mentioned above have been proven in practice. However, problems occur when the profile to be reshaped is hollow with a very thin wall, and when the shaping factor is high. Other problems arise when the material is a very high strength and thin-walled material. Such high strength materials include molybdenum or special alloys with high-strength characteristics that have proven to be especially brittle in the bending and/or reshaping process, thus becoming extremely difficult to bend.

Such high-strength special alloys (among which include not just steel, but also light-metal alloys) cannot be bent using conventional bending methods. Moreover, it has been shown that the material of these kinds of alloys are so brittle during bending and/or reshaping that it breaks, cracks, bubbles, or returns to its original state. This means that it can't be bent any longer using conventional means.

SUMMARY OF THE INVENTION

This is where the invention comes in, a purpose of which is to reshape or bend, or both, high-strength steel or light-metal alloys that cannot be bent using conventional methods of the type mentioned above, while nevertheless maintaining good shaping effectiveness with high precision.

An important feature of the invention is that at least one oscillator is assigned to at least one of the bending tools, the oscillator causing the bending tool to oscillate.

Thus, in accordance with the invention, a novel solution approach is provided in that during roll or matrix bending the respective bending tool used is subjected to an oscillation, wherein at least one of the bending tools is to be so oscillated.

According to the invention, the term "oscillator" is understood to include all suitable oscillators that are capable of causing one or more of the above bending tools (rolls and/or slides and/or pressure shoes and/or matrices) to oscillate, that oscillation consequently being transferred to the bending tool and from there to the profile to be bent and/or reshaped.

Such an oscillator can be an electromagnetic oscillator, for example, wherein a plurality of coil windings is excited by a corresponding excitation current so that the bending tool is caused to oscillate. These oscillations can act on the bending tool both in the longitudinal direction as well as in the radial direction and it is decided from case-to-case what oscillation is introduced to which bending tool or to which advancing tool.

The invention does not just pertains to the introduction of oscillations to the bending tools but also to the introduction of oscillations to tools that fit inside the profile, such as are provided in particular by means of the mandrel shaft in the longitudinal direction, the mandrel shaft being fastened to a mandrel station. In the process, the mandrel station can itself be excited by the oscillations, as can the mandrel shaft inside the hollow profile (or a tool located inside the profile), which can have its own special oscillator.

Indeed, an article by Eckart Lehfeldt: "Influence of Ultrasound on Internal Friction during Plastic Deformation of Metallic Tools" in VDI-Z-111 No. 6, pages 359-363 (1969), discloses the influence of ultrasound on internal friction in the plastic deformation of metallic materials in general. This document has been confirmed in general with the appearance of such phenomena in the microstructure of metallic materials without reference made to a bending or reshaping process.

However, in the bending and reshaping processes according to the invention that operate using a roll or matrix bending method, a characterizing feature is that the profile to be bent or reshaped is subjected to a flow process that takes place outside and inside the bending zone. Outside the zone, the material of the profile to be reshaped is under tension, whereas in the area opposite to this it is under compression. This results in a rolling effect of the profile to be bent or reshaped since at the same time the microstructure is reformed through volume changes due to the flow process in the microstructure of the profile to be reshaped.

It has now been shown that for high-strength aluminum or steel alloys, this flow process is insufficient if at least one or more of the bending tools are not caused to oscillate. This is where the invention comes in, with the awareness that concerning the tension or compression process at the profile to be bent, which simultaneously results in a volume change due to the rolling processes, is optimally supported by the production of oscillations.

Tests have shown that, when employing the present invention, for the first time it is now possible to easily reshape high strength steels and aluminum alloys (even thin-walled hollow profiles) without cracking or breaking them or causing any undesired deformation of the profile cross section.

Above, it has been explained that any arbitrary oscillator can be used as the oscillator if it is able to achieve the required oscillation frequency. Initially, an electromagnetic oscillator consisting essentially of coils excited with current was cited as the oscillator, through which a middle or high frequency oscillation can flow. Such coils can be excited at an oscillation frequency of about 50 Hz to about 20 kHz, or more.

In the process, the electromagnetic windings used can be arranged in the longitudinal direction, but electromagnetic windings can also be used that run in the direction perpendicular to it, as well as three-dimensional, current-fed electromagnetic windings that produce longitudinal oscillations as well as oscillations in the radial

direction, wherein even three-dimensional oscillations occur if oscillating electromagnetic coils are used in various directions.

In addition to the oscillators in the form of electromagnetic coils, there is a series of other oscillators that should be included in the technical teaching of the invention. In particular, resonators are considered as ultrasonic oscillators, as well as are quartz oscillators and piezo crystals.

In addition to these oscillators, mechanical oscillators are also considered such as eccentric oscillators, hydraulic oscillators, or pneumatic oscillators, in which the air or fluid cushion produces a corresponding pulsation.

As explained above, the method provides oscillations from about 50 Hz to approximately 30 kHz, wherein an oscillation in the area of about 16 to 20 kHz is preferred. In this ultrasound range, especially good results were expected from the oscillation of the bending tools.

With the measures taken according to the invention, an increase in bending effectiveness at profile is accomplished. In the process, either the bending tool itself can be oscillated or a corresponding oscillation can be introduced to the profile to be bent. Both embodiments are encompassed by the concept of the invention.

If only one method to bend hollow profiles were to be shown in the following description, this would not be understood to be limiting. The present method pertains to the bending or reshaping of solid profiles and/or semi-open profiles such as angle, T or double T profiles as well as U profiles.

Brief Description of the Drawing

In the following, the invention is explained in more detail using multiple drawing figures depicting possible embodiments. In the process, other features and advantages of

the invention derive from the drawing and their description that are essential to the invention, as shown below:

Fig.1is a schematic representation of a bending method according to the invention with the representation of different oscillators at the bending tools;

Fig. 2 shows a mandrel station to guide a double mandrel shaft, partially shown in section;

Fig. 3 is a section through the point of introduction of the double mandrel shaft into the back of the profile to be bent;

Fig. 4 is a partially modified embodiment of Fig.1 with representation of other details;

Fig. 5 is the representation of a chuck with an oscillator according to the invention;

Fig. 6 is a different embodiment of Fig. 5 with representation of other details;

Fig. 7 is a sectional view showing a first embodiment of the arrangement of coil windings in a bending roll in accordance with the invention;

Fig. 8 is a partial rear view of the design according to Fig. 7;

Fig. 9A is a second embodiment of a bending roll in section, according to the invention, showing the coil windings;

Fig. 9B is a partial rear view of the Fig. 9A embodiment, similar to Fig. 8;

Fig. 10A is a third embodiment of a bending roll according to the invention, similar to Figs. 7 and 9A;

Fig. 10B is a partial rear view of the Fig. 10A embodiment, similar to Figs. 8 and 9B;

Fig. 11 is a sectional view showing a fourth embodiment of a bending roll according to the invention;

Fig. 12 is a sectional view showing a fifth embodiment of a bending roll according to the invention;

Fig. 13A is a sectional view showing a sixth embodiment of a bending roll according to the invention;

Fig. 13B is a partial rear view of the Fig. 13A embodiment;

Fig. 14 is a sectional view showing a seventh embodiment of a bending roll according to the invention;

Fig. 15 is a rear view of the bending roll according to Fig.14;

Fig. 16 is a schematic view of a reshaping process using matrix reshaping according to the invention, in a sectional view;

Fig. 17 is a rear view of the matrix reshaping according to Fig.16; and

Fig. 18 is a side view of the matrix reshaping according to Fig. 16.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference now to the drawing, Fig.1 shows a schematic of a profile roll bending machine that consists essentially of a head machine 1 with a center shaping roll 3 inside its frame that acts on profile 20 to be bent using an initial stress of 400 kN in the direction of arrow 4, for example. Opposite shaping roll 3 is a center roll 2 that supports profile 20 from the side.

In the direction of travel behind shaping roll 3 is external support roll 6 that sits against the outside of profile 20 to be bent, whereas inner guide roll 7 sits opposite support roll 6. Another bending roll 5 can be placed at the discharge side. Rolls 5, 6, 7 can also be replaced by corresponding slides with the same effect.

Also shown is that one or more guide rolls 15 are present at the discharge end. These are used to hold the profile to be fed as the profile 20 to be bent is fed in the direction of arrow 62 (see Fig. 2).

In the back, the profile is led over a bridge 10, upon which a moveable sled 11 is located. On the sled is chuck 12 with associated jaws 14 that holds the back end of profile 20. Two mandrel rods 13 that are parallel to one another extend through the interior of profile 20, wherein each mandrel rod holds a mandrel shaft 16 at its free front end.

Figs. 2 and 3 indicate how the respective mandrel shafts 16 are introduced into the associated profile chamber of profile 20 and how the profile is pushed over the mandrel shafts.

What is important in this embodiment is that an oscillator is associated with one or more of the bending tools.

In addition, it can also be provided that in addition to the arrangement of oscillators 30 – 37 (Figs. 1 and 2) in the individual bending tools, other oscillators exist that sit against the outside of profile 20 in the form of slides. Fig.1 shows an embodiment of two vibration saddles 8, 9 opposite to one another that are located between the bending rolls 3, 6 and 2, 7, respectively. These vibration saddles 8, 9 contain their own oscillators that are suitable for exerting corresponding oscillations onto profile 20 both in the axial direction as well as in the radial direction.

The following description of the individual oscillators is not to be considered limiting. It is only necessary to provide a single oscillator at any of the bending tools on a case-by-case basis. In other embodiments, however, it is possible that a plurality of bending tools contain such oscillators. Finally, all bending tools cumulatively can be provided with corresponding oscillators.

Fig.1 is shown as an embodiment such that oscillator 30 is located in chuck 12 that exerts an oscillation onto profile 20, held there via jaws 14, that oscillation acting in the longitudinal direction.

Furthermore, schematically shown is that in one or more of the bending or support rolls 2, 3, 5, 6 one or more oscillators 31 - 35 are arranged.

Finally, Fig. 2 shows that mandrel station 17, which supports the free, rear end of mandrel rods 13, is acted upon by an associated oscillator 36. In this way, mandrel shafts 16 are also caused to oscillate as a result of mandrel rods 13 that are made to oscillate. More will be said about this later in connection with Fig. 4.

Fig. 2 shows that mandrel shaft seat18 can also be provided with an oscillator that introduces an oscillation that acts on the mandrel shaft in the vertical direction (= Z-plane) in the direction of arrow 19. In this manner, a semi-standing wave is produced in mandrel rod 13 and thus in mandrel shafts 16, which results in especially good reshaping results in the interior of the profile. Details are illustrated in this regard in Fig. 4.

In Figure 4 it can be seen that a respective mandrel rod 13 has a center hole 22 that runs in the longitudinal direction that leaves space through which to pass the cable and an oil channel. Cable 21 is used to supply coil winding 23, located inside mandrel shaft 16, with a pulsating direct current or an alternating current.

Due to the resultant magneto friction and the magnetic effects in the metallic material, the entire mandrel shaft 16 oscillates in the longitudinal direction (direction of arrow 29) and in the perpendicular direction thereto, namely in the direction of arrow 19.

The oil introduced through center hole 22 passes through mandrel shaft 16 forward in the direction of oil channels 24 that run generally perpendicular to it and radially outward. There, the oil comes to the outer surface of mandrel shaft 16 and produces an oil film 25 at the outer surface.

The front side of mandrel shaft 16 is made up of a head plate 26, the outside surface of which contains opposite casing liners 27 that assume a corresponding support function against the high deformational forces in the bending gap between shaping roll 3 and opposite center roll 2. The high-stress primary bending takes place in the area of casing liners 27, with a concomitant change in microstructure as described above, wherein the oscillation produced by coil winding 23 is transferred to casing liners 27, in particular to the inside of profile 20.

The vibration production at mandrel shaft 16 acts furthermore secondarily to minimize the friction between the outer surface of the mandrel shaft and the inner surface of the profile to be bent, in particular in the area of the bending zone.

It has been shown that excellent frictional characteristics have been achieved by the vibration production at oil film 25, since the oil is especially thin due to the back and forth motion, is distributed well and produces excellent lubrication motion at the inside surface of the profile to be reshaped. For the purposes of completeness, it should be mentioned that coil winding 23 is located in a sleeve 28 inside mandrel shaft 16.

Fig. 5 shows that chuck 12 is also provided with an oscillator 30, wherein the chucking of profile 20 is done using a chucking cylinder 38 that sits against the outside surface of profile 20. In chuck 12 is oscillator 30 that consists of a current-fed coil winding so that an oscillation is also produced via the chuck in the longitudinal direction. In addition, the figure shows that oscillator 37 is also associated with mandrel rod 13. Here, the invention provides in one embodiment that only mandrel rod 13 has an oscillator 37, in which case mandrel shaft 16 has no oscillator. In another embodiment, however, it can be provided that only mandrel shaft 16 has the oscillator described previously, whereas mandrel rod 13 does not have its own oscillator.

Other details are shown in Fig. 6. Here, oil connection 40 is provided for the introduction of oil to mandrel rod 13 at mandrel station 17. Furthermore, the mandrel rod is introduced via guide rolls 39 to chuck 12 and oscillator 30 mentioned previously is located in chuck 12.

Figs. 7 through 15 show various embodiments of bending tools that are all provided with an oscillator. Here, it is shown only by way of example that such an oscillator can consist of a current-fed coil. The invention is not limited to this, however. Instead of a current-fed coil, other oscillators can be used such as had been mentioned in the general description portion. In particular, piezoelectric crystals and other oscillators that are capable of producing ultrasonic oscillations are included here.

As a first embodiment, as shown in Figs. 7 and 8, one or more of bending rolls 2, 3, 5, 6 each are designed as metal rolls, wherein a circular notch 42 is placed at each end of the roll into which a respective coil winding 44 is inserted. This coil winding 44is circular, as indicated in Fig. 8. Such coil windings 44 can be manufactured as self-contained elements by casting them in a plastic body for example, and they are then installed as circular elements into each of the associated notches (circular notch 42) at the backs of the respective roll.

In another embodiment, the winding can be inserted directly into circular notch 42 without having to first fix it in a self-contained body.

In mass production, it is preferred that coil windings 44 can be produced and that they are self-contained so that they can be inserted as a separate element into ~~the~~ circular notch 42 with a perfect fit at each end of the roll 2, 3, 5, 6. Each end is then closed with a cover 43.

The power supply to coil windings 44 is done through slip rings in known manner and are not shown further. The slip rings are, for example, located at one end of bending rolls 2, 3, 5, 6 and are connected to an appropriate power source using associated terminals in a conventional way. Instead of the wired coupling of the excitation current for coil windings 44, an inductive (wireless) coupling can also be provided. The result is that roll surface 46 oscillates by increasing its diameter, for example forming roll surface 46, as shown in Fig. 7.

Also, the roll surfaces can be designed to make a sinusoidal oscillation along their entire axial length so that no radial, outwardly directed deformation of roll surface 46 occurs toward that roll surface, but a sine wave that extends along the axial length of roll surface 46 and deforms it in the form of a sine curve. Roll surface 46 is designed between two flanges 41of enlarged diameter, wherein these flanges can also deform in the manner shown in dashed lines.

Rolls 2, 3, 5, 6 are mounted rotatably on axial shaft 45 by means of a friction bearing, for example. In addition to a friction bearing, conventional ball bearings or other bearing supports can be used.

Fig. 9 shows a dual design of a roll 2, 3, 5, 6 compared to Fig. 7, where it can be seen that the roll design is twice that according to Fig. 7 and the two rolls abut one another near center joint 47. This leads to the result that current-fed coil windings 48 exist in especially concentrated form near joint 47, whereby a very pronounced

mechanical deformation is produced in this area. The vibration effect of such a roll 2, 3, 5, 6 is correspondingly increased in comparison to the effect according to Figs. 7 and 8.

Another increase results from the design of a roll of this type as a five-part reshaping roll that has a total of six-fold coil windings 48.

Fig. 11 shows a fourfold roll according to Fig. 9, wherein what is shown additionally is that an additional oscillator can be installed in shaft 45. This oscillator 63 causes an internal excitation of shaft 45 with a corresponding oscillation. In the center hole 50 of shaft 45 is a sleeve 51 in which one or more coil windings 52 are located. Coil winding 52 is anchored using a threaded rod 53 and the excitation voltage is introduced via connection wires 54.

In this way, the entire shaft 45 oscillates in the perpendicular direction, namely, in the direction of arrow 19, and exerts this oscillation onto the bending tool 2, 3, 5, 6 via the friction bearing mentioned above. This bending tool (bending roll) then oscillates uniquely due to the separate power supply to coil windings 44.

In the process, the excitation of the coil winding 52 in the axial oscillator 63 can be produced at another amplitude and another oscillation frequency such as the excitation of coil windings 44. This guarantees that the bending roll 2, 3, 5, 6 oscillates both in the longitudinal direction as well as in radial direction 19.

Fig. 12 shows another oscillator 55 placed on the outside of shaft 45 instead of an oscillator 63 located internal to the shaft. This oscillation package consists essentially of external coil winding 56 that is located in an associated support that is placed on shaft 45 as tightly as possible. In this way, shaft 45 experiences an oscillation in the longitudinal direction and in the perpendicular direction. This oscillation is conveyed to roll 2, 3, 5, 6 as well via the associated friction bearing.

Figs. 13A and 13B shows in another embodiment that coil windings 58 are located near a bushing 57 that forms a friction bearing with shaft 45 as a special part. Bushing 57 is therefore easily replaced and can be replaced by other bushings with other coil windings 58.

It supports a center support ring 59 of enlarged diameter through which the bending forces are absorbed, such forces acting in particular on the middle range of the rolls 2, 3, 5, 6.

Figs.14 and 15 show in another embodiment that rolls 2, 3, 5, 6 can also have axial holes 60 that are distributed along the periphery and that sit parallel to one another. Coil winding 61 fits in each axial hole 60 and all coil windings 61 are fed by a common power source (not shown). Here as well, the two ends are likewise covered by a single cover 43.

Figs. 16 – 18 show in general a reshaping process that uses known matrix reshaping methods. In the process, a bending matrix 70 is provided in two or three spatial axes. This matrix can be moved in the directions of arrows 71, 72, 75 and in addition can be rotated in the rotational directions 73, 74.

The profile 20 to be bent extends through the passage gap of bending matrix 70. Mandrel shaft 16 is led inside this profile (as shown above) in the bending zone, the shaft being moved by a mandrel rod 13. One or more fixed matrices 64 are located at a distance from-bending matrix 70 that sit against the profile to be bent and that have lubricating pad 67 at these seat surfaces.

What is important at this point is that at least one oscillator 65 is assigned to bending matrix 70, that oscillator producing an approximately centric (star-shaped) oscillation at the passage gap in bending matrix 70 so that it rhythmically enlarges and reduces, and thus communicates a corresponding vibration to profile 20 to be bent.

In addition, fixed matrices 64 can be assigned their own oscillators 66. These oscillators act on lubricating pad 67 in particular, which as a result are caused to oscillate in order to produce an improved lubrication effect on profile 20 being fed through at that point. The profile to be bent is fed through in the direction of arrow 68 through fixed matrices 64 and the bending matrix 70 that follows.

It is evident that mandrel rod 13 and/or mandrel shaft 16 can be acted upon by its own oscillator as was explained above in the general description. Likewise, it is possible to impart the profile itself with an oscillation via chuck 12. Also, in this exemplary embodiment according to Figures 16 - 18, the lubrication in mandrel shaft 16 can occur with the aid of an oscillator as was explained in Fig. 4.

All discussions concerning the roll bending method therefore apply to the matrix bending process according to Figs. 16 - 18.